植 物 分 类 学 报 39 (6):502~514 (2001)
Acta Phytotaxonomica Sinica

国产 12 种乌头属和 18 种翠雀属植物的细胞学研究

杨亲二
(中国科学院植物研究所系统与进化植物学开放研究实验室 北京 100093)

Cytology of 12 species in *Aconitum* L. and of 18 species in *Delphinium* L. of the tribe Delphineae (Ranunculaceae) from China

YANG Qin-Er
(*Laboratory of Systematic and Evolutionary Botany*, *Institute of Botany*, *the Chinese Academy of Sciences*, Beijing 100093)

Abstract Cytology of 12 species in *Aconitum* L. and of 18 species in *Delphinium* L. of the tribe Delphineae (Ranunculaceae) from China have been investigated. Only *A*. *crassiflorum* is a tetraploid with the chromosome number of $2n = 32$, and all the other *Aconitum* species studied are diploids with $2n = 16$. In *A*. *piepunense*, up to six B-chromosomes were observed. All the *Delphinium* species are diploids with $2n = 16$; their karyotypes are very similar among the species, and are distinctly distinguishable from those of *Aconitum* species with respect to the chromosome size, chromosome morphology and karyotype asymmetry. From a cytological view, *Delphinium* seems to be more advanced than *Aconitum*, as the karyotypes in *Delphinium* are more asymmetric than those in *Aconitum*.

Key words *Aconitum* L.; *Delphinium* L.; Chromosome; Karyotype evolution

The tribe Delphineae of the Ranunculaceae, which consists of three genera, i.e. *Aconitum* L., *Delphinium* L. and *Consolida* (DC.) S. F. Gray, is characterized by having the zygomorphic flower. The karyotypes in the three genera are all highly asymmetric and are regarded to be associated with the highly specialized zygomorphic flower (Stebbins, 1971; Lewitsky, 1931). Hence intensive cytological research may be of some help for a better understanding of the gross-morphological evolution in this tribe.

Although *Consolida*, which has the single spurred petal and the single carpel, is generally considered as the most advanced genus in the tribe and might have been directly derived from *Delphinium* (Tamura, 1995), the relationship between *Aconitum* and *Delphinium* has long been a controversial matter. Most of the gross-morphological characters in the two genera seem to exhibit parallel evolution, so it is difficult to determine their phylogenetic relationships based on gross-morphological characters.

The chromosomes of the Chinese *Aconitum* species have been quite extensively studied (Yang, 1996; Yang & Gong, 1995; Yang *et al*., 1994, 1993, 1989; Shang, 1985; Shang & Li, 1984), but those of the Chinese *Delphinium* species, up to more than 100 in number (Wang, 1979), are

---

Received 2 February 2001; accepted 5 April 2001
Supported by the National Natural Science Foundation of China (NSFC30070057) and a Key Project Grant from the Chinese Academy of Sciences (National Resources and Environment).

poorly made in most standard references, excepting that the chromosomes of ten species were observed and reported by Liu and He (1999), and Yang (1996).

This paper is to report the cytological observations on 12 *Aconitum* and 18 *Delphinium* species, all from China.

1 Material and Methods

All the plants studied were collected in the field from China, mostly from Yunnan, Sichuan and Qinghai (Table 1). They were cultivated in pots in the experimental garden of Kunming Institute of Botany, the Chinese Academy of Sciences, before their root tips were harvested for the cytological study. Actively growing root tips were pretreated in 0.1% colchicine at about 20℃ for three hr before they were fixed in Carnoy Ⅰ (glacial acetic acid : absolute ethanol = 1 : 3) at 4℃ for 30 min, then they were macerated in 1 : 1 mixture of 1 mol/L hydrochloric acid and 45% acetic acid at 60℃ for two min, and stained and squashed in 1% aceto-orcein.

The symbols used to describe the karyotypes followed Levan *et al*. (1964).

The voucher specimens were deposited in the Herbarium of Institute of Botany, the Chinese Academy of Sciences (PE).

2 Results

2.1 *Aconitum* L.

Twelve species in this genus were studied. Only *A. crassiflorum* was a tetraploid with the chromosome number of 2n = 32 (Fig. 8), all the other species were diploids with 2n = 16 (Figs. 1 ~ 7; Figs. 9 ~ 18).

Four taxa studied, i.e. *A. scaposum*, *A. crassiflorum*, *A. sinomontanum* and *A. barbartum* var. *hispidum*, which all have perennial rhizomes, are members of *Aconitum* subgen. *Lycoctonum*. The karyotypes of the three diploid species were very similar (Fig. 7; Figs. 9 ~ 10). The first two chromosome pairs were obviously larger than the remaining ones, one pair being median-centromeric (m) and the other submedian-centromeric (sm). The third to seventh chromosome pairs were moderately large, the fifth pair being submedian-centromeric, and the other four pairs subterminal-centromeric (st). The eighth chromosome pair was obviously smaller and submedian-centromeric. In *A. sinomontanum* and *A. barbatum* var. *hispidum*, one or two satellites were observed on the short arms of the eighth chromosome pair (Figs. 9 ~ 10).

The karyotype of the tetraploid species, *A. crassiflorum* (Fig. 8), was quite different from those of the diploid ones. Those smaller chromosomes (the fifth to 16th pairs) in this tetraploid species were mostly median- or submedian-centromeric rather than subterminal-centromeric as in the diploid species.

Eight species studied, i. e. *A. tanguticum*, *A. hemsleyanum*, *A. delavayi*, *A. fengii*, *A. piepunense*, *A. liljestrandii*, *A. tongolense* and *A. legendrei*, which all have biennial tubers, are members of *Aconitum* subgen. *Aconitum*. They were all diploids with the chromosome number of 2n = 16 (Figs. 3 ~ 6; Figs. 11 ~ 18). Their karyotypes (Figs. 11 ~ 18) were very similar to each other. The first two chromosome pairs were obviously larger than the remaining ones, one pair being median-centromeric, and the other submedian-centromeric. The third to seventh chromosome pairs were moderately large, and are mostly median- or submedian-centromeric. The eighth chromosome

Table 1 Source of material studied and chromosome counts

Taxon	Provenance	Voucher	2n
Aconitum L.			
Subgen. *Lycoctonum* (DC.) Peterm.			
A. *scaposum* Franch.	Huadianba, Cangshan Mt., Dali, Yunnan	Q.E. Yang 94-20	16
A. *crassiflorum* Hand.-Mazz	Gaoertushan Mt., Yajiang, Sichuan	Y.B. Luo 95	32
A. *sinomontanum* Nakai	Mengda, Xunhua, Qinghai	Q.E. Yang 95-07	16
A. *barbatum* var. *hispidum* DC.	Majiagou, Jishan, Shanxi	Y.B. Luo 09	16
Subgen. *Aconitum*			
A. *tanguticum* (Maxim.) Stapf	Yakou, Datong, Qinghai	Q.E. Yang 95-30	16
A. *hemsleyanum* Pritz.	Lidiping, Weixi, Yunnan	Q.E. Yang & H.Z. Kong 98-457	16
A. *delavayi* Franch.	Xiaohuadianba, Cangshan Mt., Dali, Yunnan	Q.E. Yang 94-04	16
A. *fengii* W. T. Wang	Kena, Weixi, Yunnan	Q.E. Yang & H.Z. Kong 98-199	16
A. *piepunense* Hand.-Mazz.	Bisanggu, Zhongdian, Yunnan	Q.E. Yang & H.Z. Kong 98-229	16 + 0 – 6B
A. *liljestrandii* Hand.-Mazz.	Gaoertushan Mt., Yajiang, Sichuan	Y.B. Luo 93	16
A. *tongolense* Ulbr.	Zhegushan Mt., Lixian, Sichuan	Y.B. Luo 59	16
A. *legendrei* Hand.-Mazz.	Shimian, Sichuan	Q.E. Yang 93-02	16
Delphinium L.			
Subgen. *Delphinastrum* (DC.) W. T. Wang			
Sect. *Aconitoides* W. T. Wang			
D. *forrestii* Diels	Hongshan Mt., Zhongdian, Yunnan	Q.E. Yang & H.Z. Kong 98-324	16
D. *oxycentrum* W. T. Wang	Hongshan Mt., Zhongdian, Yunnan	Q.E. Yang & H.Z. Kong 98-329	16
D. *trichophorum* Franch.	Qiakerixiang, Zêkog, Qinghai	Q.E. Yang 95-21	16
Sect. *Elatopsis* Huth			
D. *kansuense* W. T. Wang	Xiazheng Temple, Pingan, Qinghai	Q.E. Yang 95-23	16
D. *smithianum* Hand.-Mazz.	Hongshan Mt., Zhongdian, Yunnan	Q.E. Yang & H.Z. Kong 98-325	16
D. *pylzowii* Maxim.	Yakou, Datong, Qinghai	Q.E. Yang 95-31	16
Sect. *Pogonanthum* W. T. Wang			
D. *delavayi* Franch.			
var. *delavayi*	Yulongshan Mt., Lijiang, Yunnan	Q.E. Yang 94-137	16
var. *pogonanthum* (Hand.-Mazz.) W.T. Wang	Bitahai, Zhongdian, Yunnan	Q.E. Yang 94-93	16
D. *umbrosum* Hand-Mazz.	Kena, Weixi, Yunnan	Q.E. Yang & H.Z. Kong 98-184	16
D. *bonvalotii* Franch.	917 Forestry Station, Muli, Sichuan	Q.E. Yang 93-22	16
D. *spirocentrum* Hand.-Mazz.	Huadianba, Cangshan Mt., Dali, Yunnan	Q.E. Yang 94-19	16
D. *bulleyanum* Forrest ex Diels	Bitahai, Zhongdian, Yunnan	Q.E. Yang 94-94	16
Sect. *Delphinastrum*			
D. *ceratophorum* Franch.	Lidiping, Weixi, Yunnan	Q.E. Yang 94-72	16
D. *tenii* Lévl.	Bitahai, Zhongdian, Yunnan	Q.E. Yang & H.Z. Kong 98-159	16
D. *yunnanense* Franch.	Xishan, Kunming, Yunnan	Q.E. Yang 94-61	16
D. *coleopodum* Hand.-Mazz.	Yulongshan Mt., Lijiang, Yunnan	Q.E. Yang 94-116	16
D. *likiangense* Franch.	Tuguancun, Zhongdian, Yunnan	Q.E. Yang & H.Z. Kong 98-526	16
D. *grandiflorum* L.	Miyaluo, Lixian, Sichuan	Y.B. Luo 61	16
D. *beesianum* W. W. Smith	Napahai, Zhongdian, Yunnan	Q.E. Yang 94-89	16

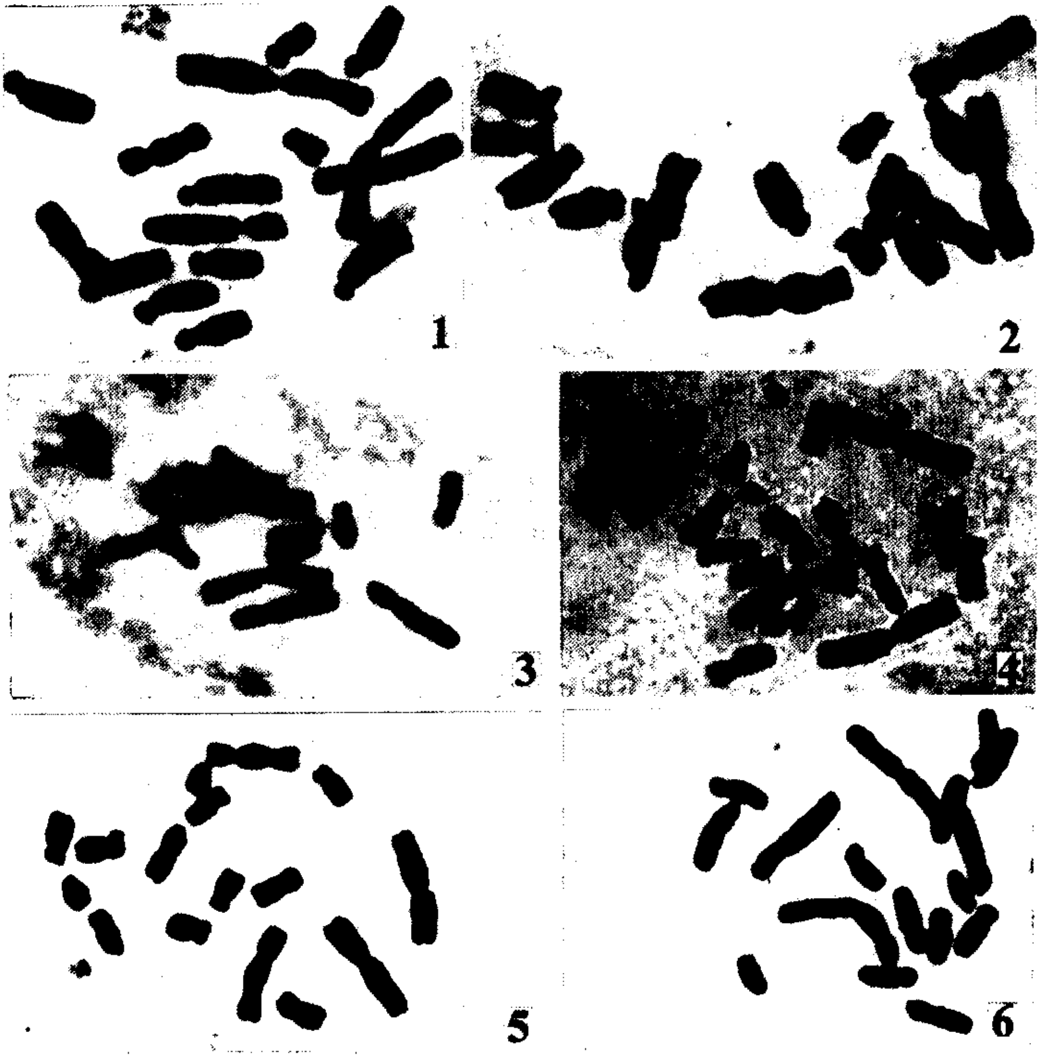
pair was obviously smaller and submedian-centromeric. One or two satellites were observed on the short arms of the eighth chromosome pair in *A*. *tanguticum* (Fig. 11), of the fifth pair in *A*. *hemsleyanum* (Fig. 12) and in *A*. *fengii* (Fig. 14), of the seventh pair in *A*. *delavayi* (Fig.

13), and of the fourth pair in *A. piepunense* (Fig. 15), respectively.

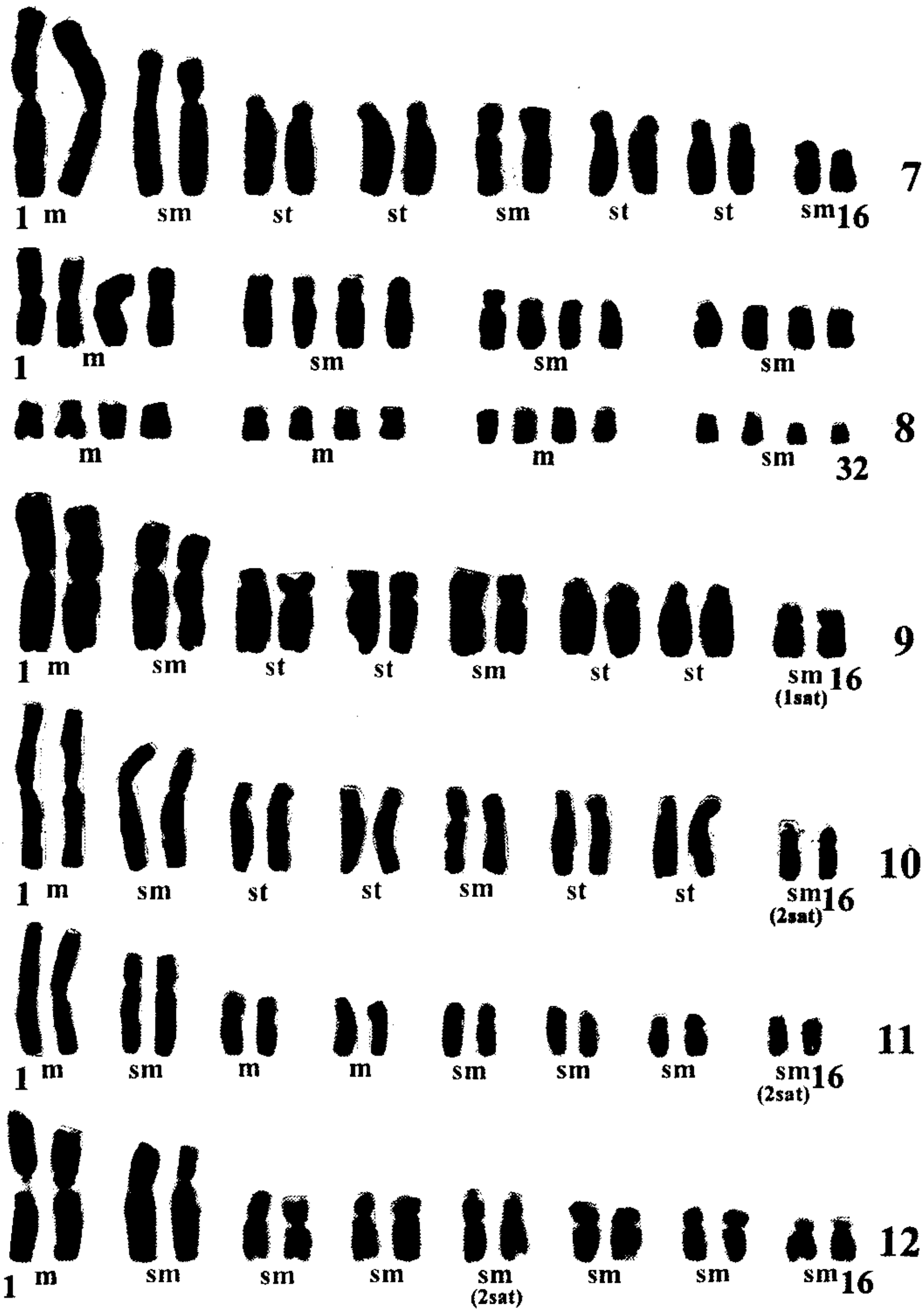
In *A. piepunense*, up to 6 B-chromosomes were observed (Fig. 4; Fig. 15), but in some cells only three or even no B-chromosomes were found. The number of B-chromosomes seemed to be unstable not only within the population but also in the roots of the same individual, just as in the case of *A. tuguancunense* (Yang, 1995). A more detailed observation on the B-chromosomes in this species is needed.

2.2 *Delphinium* L.

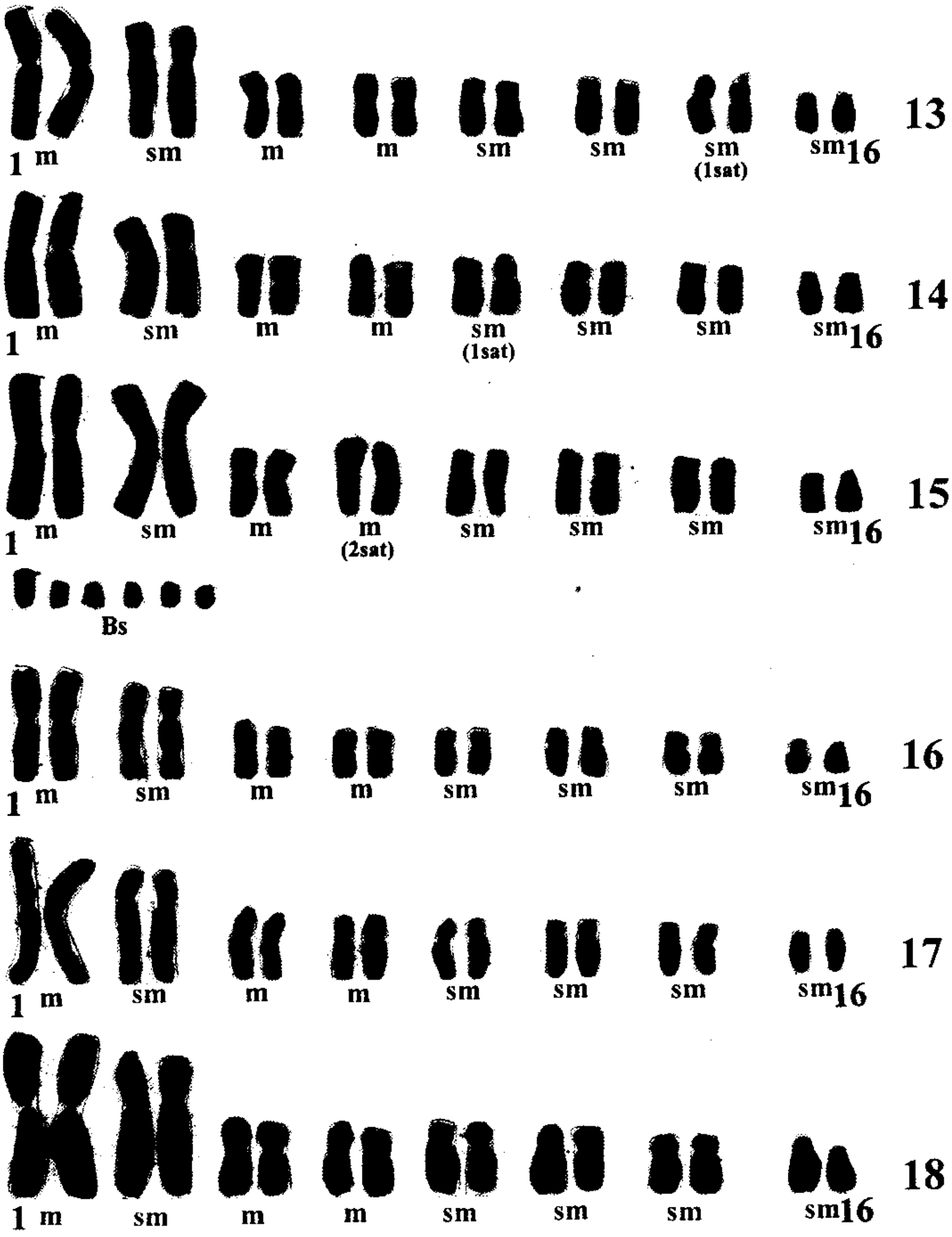
The 18 species studied were all found to be diploids with the chromosome number of 2n = 16 (Figs. 19 ~ 45). Their karyotypes were also very similar to each other (Figs. 27 ~ 45). The first two chromosome pairs were obviously larger than the remaining ones, one pair being median-centromeric and the other submedian-centromeric. The third to seventh chromosome pairs were moderately



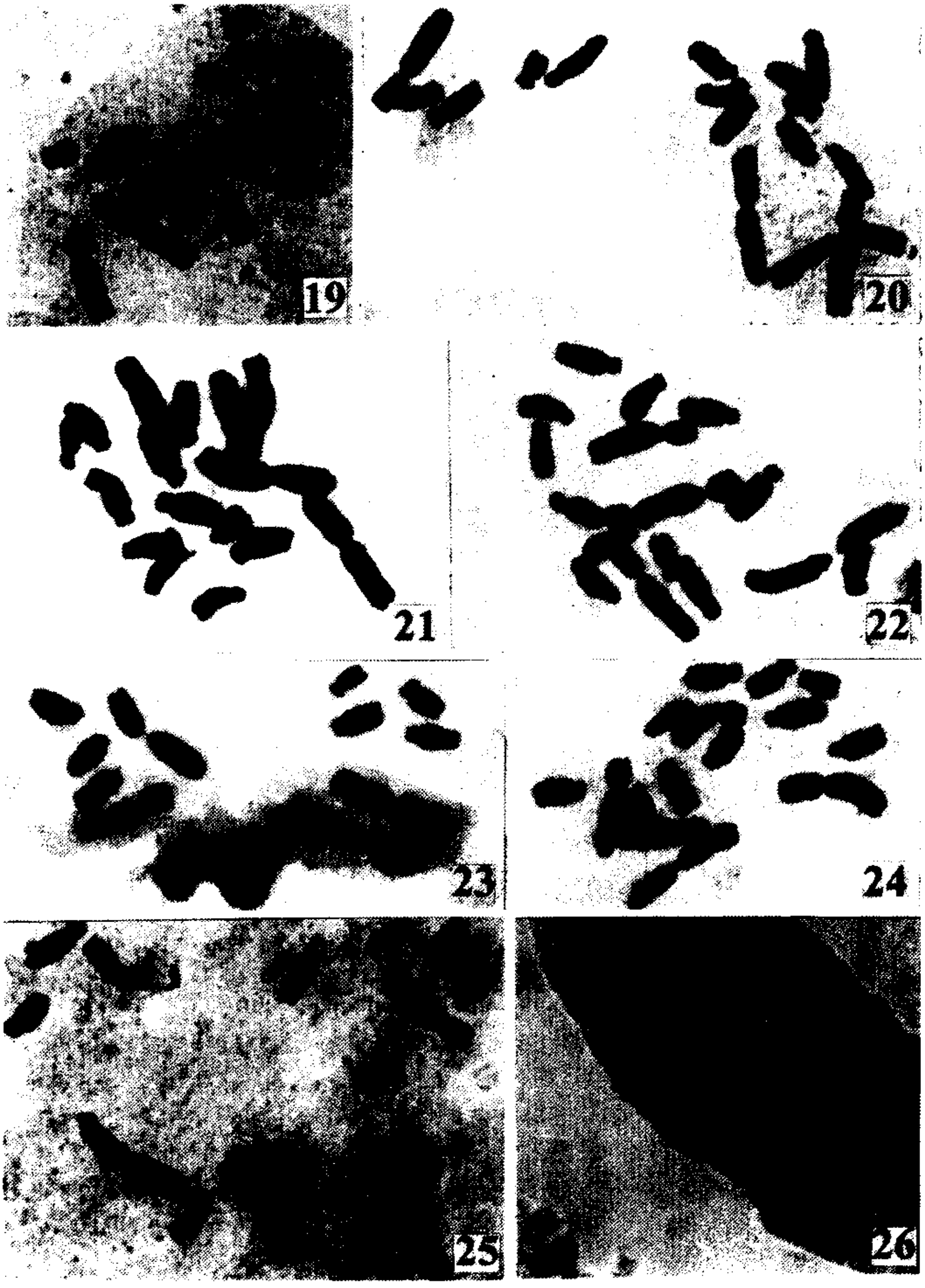
Figs. 1 ~ 6 Photomicrographs of chromosomes in six species of *Aconitum* 1. *A. scaposum*; 2. *A. sinomontanum*; 3. *A. tanguticum*; 4. *A. piepunense*; 5. *A. liljestrandii*; 6. *A. tongolense* (all × 1940).


1 m sm st st sm st st sm 16
7
1 m sm sm sm
m m m sm 32
8
1 m sm st st sm st st sm (1sat) 16
9
1 m sm st st sm st st sm (2sat) 16
10
1 m sm m m sm sm sm sm (2sat) 16
11
1 m sm sm sm sm (2sat) sm sm sm 16
12

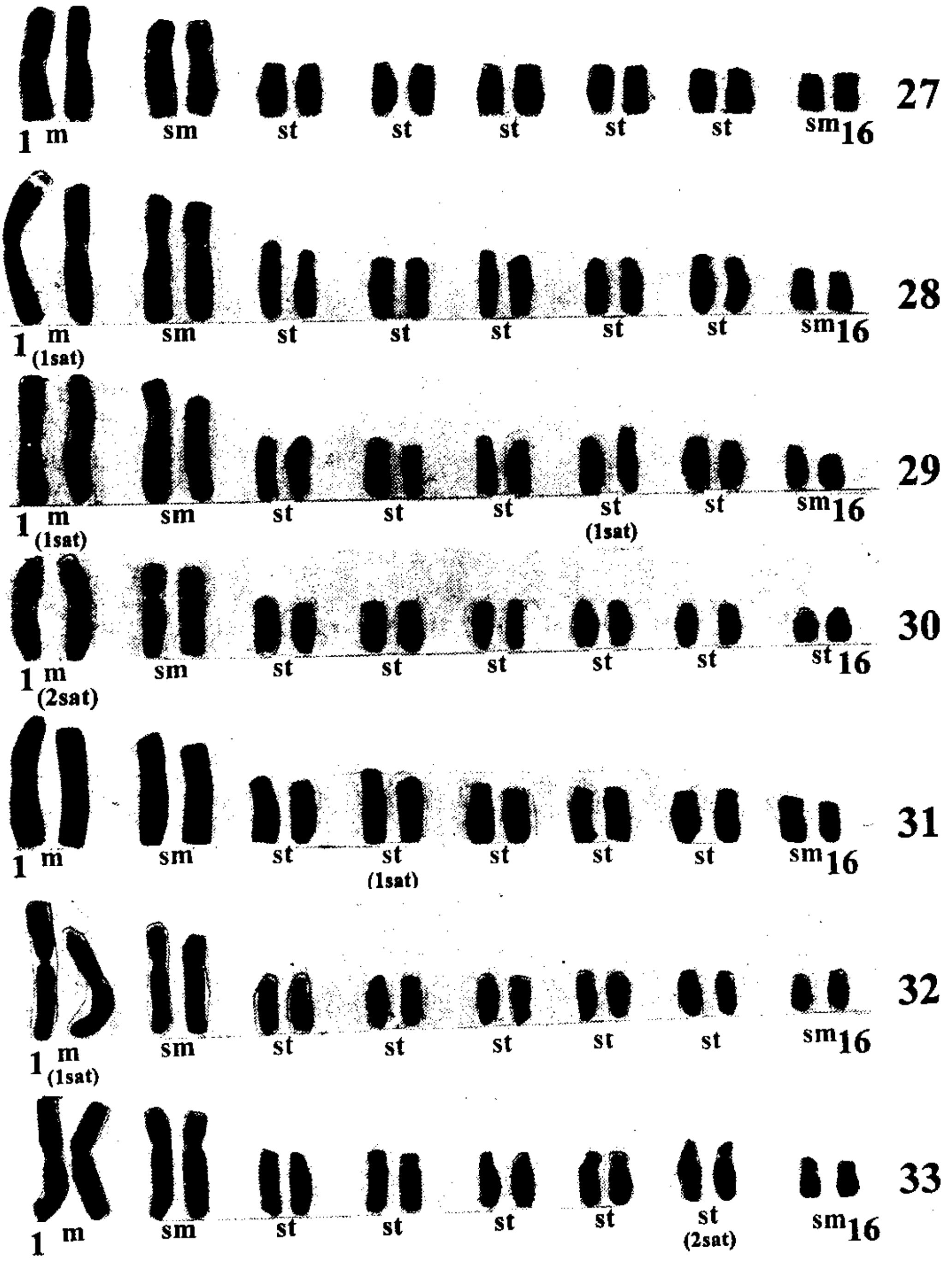
Figs. 7 ~ 12 Karyotypes in six species of *Aconitum* 7. *A. scaposum*; 8. *A. crassiflorum*; 9. *sinomontanum*; 10. *A. barbatum* var. *hispidum*; 11. *A. tanguticum*; 12. *A. hemsleyanum* (all × 1940).


1 m sm m m sm sm sm (1sat) sm 16
13
1 m sm m m sm (1sat) sm sm sm 16
14
1 m sm m m (2sat) sm sm sm sm 16
15
Bs
1 m sm m m sm sm sm sm 16
16
1 m sm m m sm sm sm sm 16
17
1 m sm m m sm sm sm sm 16
18

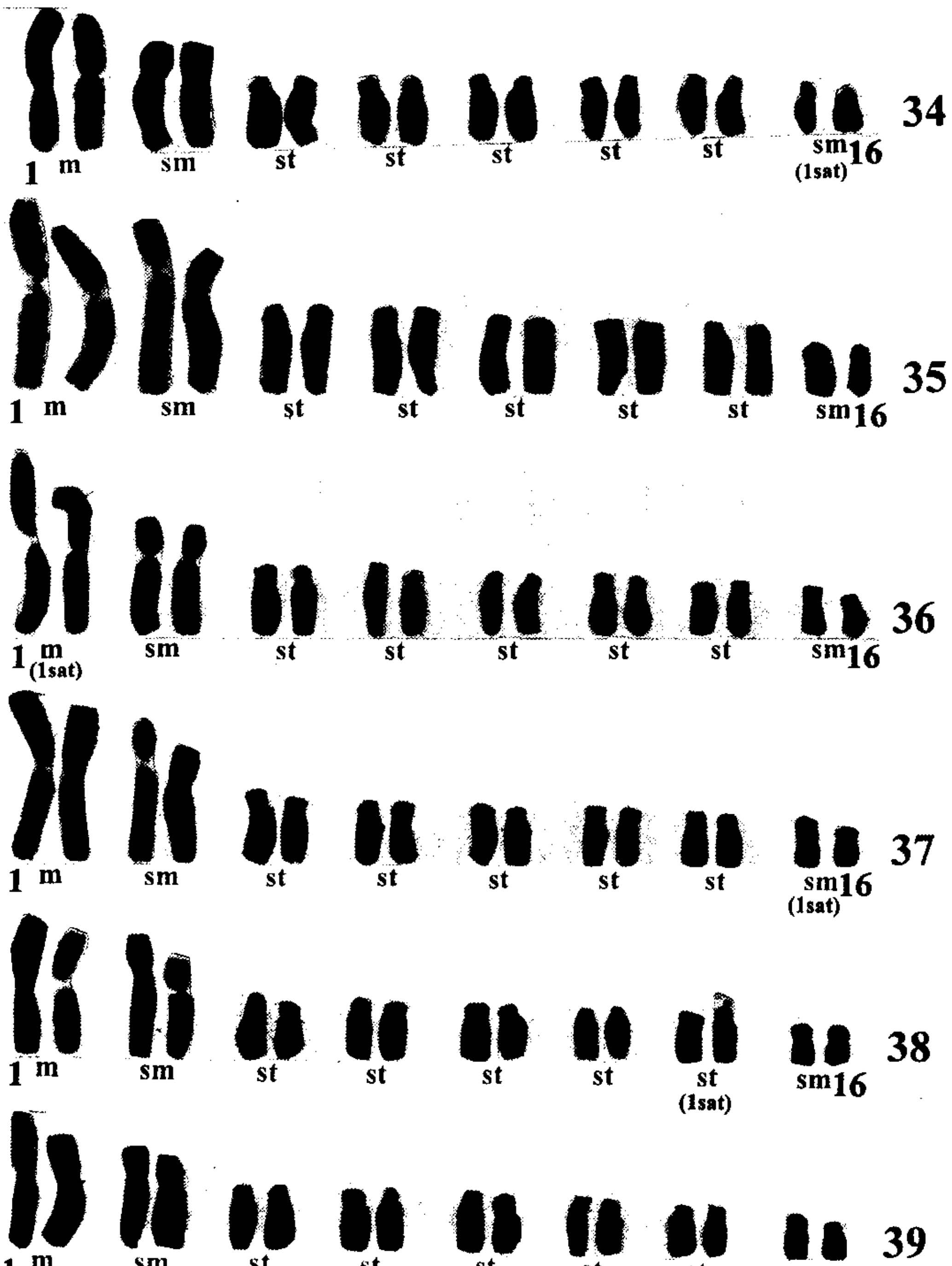
Figs. 13 ~ 18 Karyotypes in six species of *Aconitum* 13. *A. delavayi*; 14. *A. fengii*; 15. *A. piepunense*; 16. *A. liljestrandii*; 17. *A. tongolense* (all × 1940); 18. *A. legendrei* (× 2600).



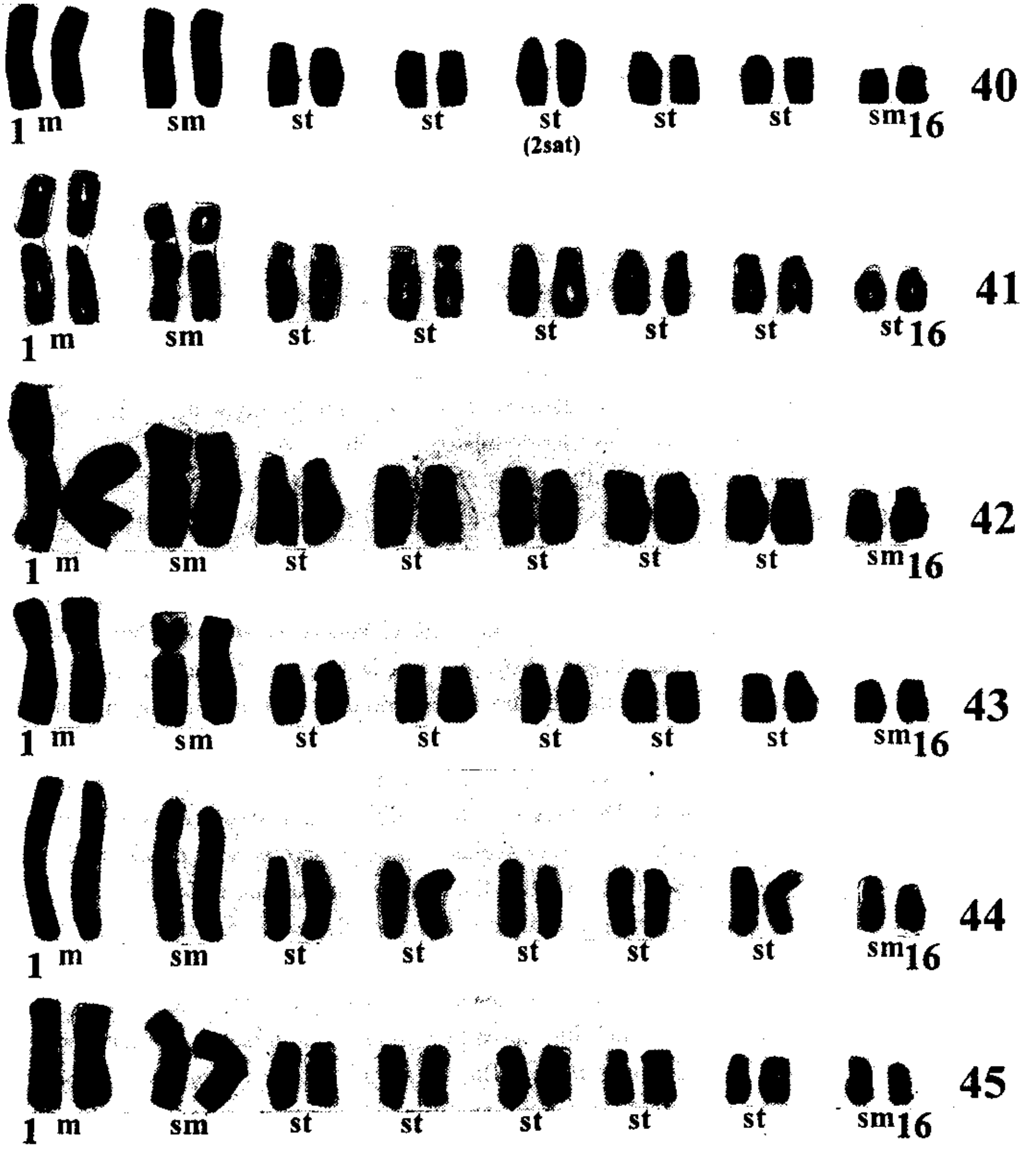
Figs. 19 ~ 26 Photomicrographs of chromosomes in eight taxa of *Delphinium* 19. *D. forrestii*; 20. *D. oxycentrum*; 21. *D. delavayi* var. *pogonanthum*; 22. *D. bonvalotii*; 23. *D. bulleyanum*; 24. *D. ceratophorum*; 25. *D. smithianum*; 26. *D. tenii* (all × 1940).


1 m sm st st st st st sm 16 27
1 m (1sat) sm st st st st st sm 16 28
1 m (1sat) sm st st st st (1sat) st sm 16 29
1 m (2sat) sm st st st st st st 16 30
1 m sm st st (1sat) st st st sm 16 31
1 m (1sat) sm st st st st st sm 16 32
1 m sm st st st st st (2sat) sm 16 33

Figs. 27 ~ 33 Karyotypes in seven taxa of *Delphinium* 27. *D. forrestii*; 28. *D. oxycentrum*; 29. *D. trichophorum*; 30. *D. kansuense*; 31. *D. smithianum*; 32. *D. plyzowii*; 33. *D. delavayi* (all × 1940).


1 m sm st st st st st sm (1sat) 16 34
1 m sm st st st st st sm 16 35
1 m (1sat) sm st st st st st sm 16 36
1 m sm st st st st st sm (1sat) 16 37
1 m sm st st st st st (1sat) sm 16 38
1 m sm st st st st st sm 16 39

Figs. 34 ~ 39 Karyotypes in six taxa of *Delphinium* 34. *D. delavayi* var. *pogonanthum*; 35. *D. umbrosum*; 36. *D. bonvalotii*; 37. *D. spirocentrum*; 38. *D. bulleyanum*; 39. *D. ceratophorum* (all × 1940).


1 m sm st st st (2sat) st st sm 16 40
1 m sm st st st st st st 16 41
1 m sm st st st st st sm 16 42
1 m sm st st st st st sm 16 43
1 m sm st st st st st sm 16 44
1 m sm st st st st st sm 16 45

Figs. 40 ~ 45 Karyotypes in six species of *Delphinium* 40. *D*. *tenii*; 41. *D*. *yunnanense*; 42. *D*. *coleopodum*; 43. *D*. *likiangense*; 44. *D*. *grandiflorum*; 45. *D*. *beesianum* (all × 1940).

large and commonly subterminal-centromeric. The eighth pair was obviously smaller and submedian-centromeric or occasionally subterminal-centromeric.

One or two small satellites were observed on the short arms of the first chromosome pair in *D*. *oxycentrum* (Fig. 28), *D*. *trichophorum* (Fig. 29), *D* . *kansuense* (Fig. 30), *D*. *plyzowii* (Fig. 32) and *D*. *bonvalotii* (Fig. 36), of the sixth pair in *D*. *trichophorum* (Fig. 29), of the fourth pair in *D*. *smithianumi* (Fig. 31), of the seventh pair in *D*. *delavayi* (Fig. 33) and *D*. *bulleyanum* (Fig. 38), of the eighth pair in *D*. *delavayi* var. *pogonanthum* (Fig. 34) and *D*. *spirocentrum* (Fig. 37), and of the fifth pair in *D*. *tenii* (Fig. 40), respectively.

3 Discussion

3.1 Polyploidy in *Aconitum* subgen. *Lycoctonum*

Lewis (1980), and Tamura (1995) pointed out that in *Aconitum* subgen. *Lycoctonum* all the species are diploids, but in fact, as shown by the present results and those previously reported (Yang, 1996; Yang *et al*., 1994), at least four taxa in this subgenus, i. e. *A*. *brevicalcaratum* and its variety *A*. *brevicalcaratum* var. *parviflorum*, *A*. *crassiflorum* and *A*. *sinomontanum* var. *angustius* are tetraploids, and in *A*. *sinomontanum* , a tetraploid cytotype has also been reported from Jinfoshan Mt., Sichuan (Shang & Li, 1984). *A* . *brevicalcaratum* and *A*. *crassiflorum* are two species of special interest in the cytotaxonomy of this subgenus. Both of them are distributed in NW Yunnan and SW Sichuan, and are very similar to each other in external morphology (Yang, 1999). Lauener and Tamura (1978), and Tamura (1995) put them in two relatively distant series. In my opinion, these two species are very closely related to each other.

3.2 High similarity of karyotypes in the genus *Delphinium*

According to Kurita (1957), the karyotypes in *Delphinium* fall into two different basic types on the basis of the morphology of the second and the third chromosome pairs (*Delphinium ajacis*, which has another basic karyotype as reported by Kurita, is actually a species belonging to the genus *Consolida*). Blanché (1990), and Blanché *et al*. (1997, 1991) also considered that there exist obvious differences of karyotypes between subgen. *Delphinastrum* and subgen. *Delphinium* and pointed out that the karyotypes in the former subgenus are characterized by having a higher proportion of metacentric and/or submetacentric chromosomes, while those in the latter subgenus are characterized by having a higher proportion of acrocentric and/or telocentric chromosomes. The present results have shown that the karyotypes of the 18 species studied, which are representatives from different sections of the subgen. *Delphinastrum*, are very similar among the species with respect to the chromosome size and chromosome morphology if putting the number and position of satellites out of consideration, and have the same proportion of acrocentric and/or telocentric chromosomes as those of the subgen. *Delphinium*. Three species studied here, *D*. *forrestii*, *D*. *oxycentrum* and *D*. *trichophorum*, belong to sect. *Aconitoides*, a morphologically most primitive group in *Delphinium*, but their karyotypes show no any essential differences from those of the relatively advanced species, such as *D*. *grandiflorum* and *D*. *beesianum*. The karyotype of *D*. *pentagynum* reported by Blanché(1990), a species of subgen. *Delphinastrum*, in which the fifth and seventh chromosome pairs were shown to be median-centromeric, is quite different from the karyotypes of the species in this subgenus here reported. Therefore the karyotype of *D*. *pentagynum* needs a re-examination. The karyotype of 2n = 8m + 6sm reported by Yang and Wu (1993) for *D*. *candelabrum* var. *monanthum* (Hand.-Mazz.) W. T. Wang can be safely regarded as a mistake caused by misidentification of material. It is not likely that there is such a symmetric karyotype in the genus *Delphinium*.

In chromosome size, all the 18 species studied have also not shown distinct difference from each other, although Al-Kelidar and Richards (1981) reported that there exist some differences in chromosome size among some species in this genus and pointed out that species with smaller mean chromosome length can be considered to be karyologically derivative.

3.3 Karyotypic differences between *Aconitum* and *Delphinium*

The karyotypes of the diploid species of *Aconitum* subgen. *Lycoctonum* are obviously different from those of the diploid species of *Aconitum* subgen. *Aconitum* not only in chromosome size but also in chromosome morphology, as has been reiterated by Yang (1996), Yang *et al*. (1994, 1993), Shang & Li (1984) and Schafer & La Cour (1934), although the karyotypes of the tetraploid species in subgen. *Lycoctonum* have greatly obscured such differences. Nevertheless, the karyotypes of *Delphinium* are readily distinguishable from those of subgen. *Lycoctonum* and subgen. *Aconitum* as well. Although the karyotypes of *Delphinium* and *Aconitum* subgen. *Lycoctonum* are very similar with respect to the chromosome composition, which is characterized by having a higher proportion of subterminal-centromeric chromosomes, the chromosomes of *Delphinium* are obviously smaller than those of *Aconitum* subgen. *Lycoctonum*. On the contrary, although the karyotypes of *Delphinium* are similar to those of *Aconitum* subgen. *Aconitum* in the chromosome size, they are different from each other in chromosome composition, which can be seen from the fact that the third to the seventh chromosome pairs in *Delphinium* are all subterminal-centromeric, while the counterparts in *Aconitum* subgen. *Aconitum* are mostly median-centromeric or median-centromeric. The karyotypes of *Delphinium*, with a higher proportion of subterminal-centromeric chromosomes, have a higher intrachromosomal asymmetry than those of *Aconitum*. From the chromosomal data, therefore, the genus *Delphinium* may be more advanced than the genus *Aconitum*. The karyotypic evolutionary trend in the tribe Delphineae seems to be in accordance with that in the whole Ranunculaceae, that is, toward increasing asymmetry of the karyotype.

Acknowledgments I would like to express my sincere thanks to Mr. Fang Zhen-Dong of Gesang Flower Co. Ltd., Zhongdian County, Yunnan, and Drs. Luo Yi-Bo and Kong Hong-Zhi of Laboratory of Systematic and Evolutionary Botany, Institute of Botany, the Chinese Academy of Sciences, for their help in collecting living materials. I am grateful to Professor Gu Zhi-Jian of Kunming Institute of Botany, the Chinese Academy of Sciences, for kindly leaving his research facilities at my disposal.

References

Al-Kelidar R K, Richards A J, 1981. Chromosomal indications of evolutionary trends in the genus *Delphinium* L. Cytologia, 46: 623 ~ 633

Blanché C, 1990. *Delphinium* L. subgen. *Delphinium*: origin and evolutionary trends. Coll Bot, 19: 75 ~ 95

Blanché C, 1991. Revisio biosistematica del genere *Delphinium* L. a la Peninsula Iberica I a les Illes Baleares. Barcelona: Arxius de la Seccio de Ciencies, Institut d Estudis Catalans

Blanché C, Molero J, Rovira M A *et al*., 1997. *Delphinium* L. subgen. *Delphinium* in the Iberian Peninsula and North Africa: a new taxonomic approach. Lagascalia, 19: 59 ~ 82

Kurita M, 1957. Chromosome studies in Ranunculaceae Ⅴ. Karyotypes of the subtribe Delphininae. Rep Biol Inst Ehime Univ, 3: 1 ~ 8

Lauener L A, Tamura M, 1978. A synopsis of *Aconitum* subgenus *Paraconitum*: Ⅰ. Notes Roy Bot Gard Edinb, 37: 113 ~ 124

Levan A, Fredga K, Sandberg A A, 1964. Nomenclature for centromeric position on chromosomes. Hereditas, 52: 201 ~ 220

Lewis W H, 1980. Polyploidy in angiosperms: dicotyledons. In: Lewis W H ed. Polyploidy, Biological Relevance. New York and London: Plenum Press. 241 ~ 268

Lewitsky G A, 1931. The karyotype in systematics. Bull Appl Bot Genet Pl Breed, 27: 220 ~ 240

Liu J Q, He T N, 1999. Karyotypes of seven taxa of *Delphinium* from southern Qinghai. Acta Bot Yunnan, 21: 471 ~ 476

Schafer B, La Cour L, 1934. A chromosome survey of *Aconitum* L. Ann Bot, 48: 693 ~ 713

Shang X M, 1985. Chromosome studies of subgenus *Gymnaconitum* endemic to China and *Beesia* (Ranunculaceae). Acta Phytotax Sin, 23: 270 ~ 274

Shang X M, Li Z L, 1984. Chromosome studies of 10 species of *Aconitum* in China. Acta Phytotax Sin, 22: 378 ~

385

Stebbins G L, 1971. Chromosomal Evolution in Higher Plants. London: Edward Arnold

Tamura M, 1995. Ranunculaceae. In: Hiepko P ed. Die Natürlichen Pflanzenfamilien. zwei Aufl, 17a(4). Berlin: Duncker and Humblot

Yang Q E, 1996. A karyotype study of 15 species in the tribe Delphineae (Ranunculaceae) from China. Acta Phytotax Sin, 34: 39～47

Yang Q E, Gong X, 1995. A new species of the genus *Aconitum* L. from Yunnan, with an observation on its B chromosomes. Acta Phytotax Sin, 33: 572～575

Yang Q E, Gu Z J, Wu Z Y, 1994. A karyomorphological study in *Aconitum* subgen. *Lycoctonum* (Ranunculaceae) from Yunnan. Acta Bot Yunnan, 16: 61～74

Yang Q E, Gu Z J, Wu Z Y *et al*., 1989. A karyomorphological study of some Yunnan species of *Aconitum* L. (Ranunculaceae). La Kromosomo, Ⅱ-55-56: 1838～1860

Yang Q E, Wang X Q, Hong D Y, 1993. A karyotype study of 7 species of *Aconitum* L. from China. J Plant Resour & Environ, 2: 33～38

Yang Y P, Wu S G, 1993. Chromosomal reports on some plants of Hohxil Region, Qinghai (1). Acta Bot Yunnan, 15: 173～178

Wang W T, 1979. *Delphinium* L. In: Flora Reipublicae Popularis Sinicae. Beijing: Science Press. 27: 326～465

摘要 研究了12种乌头属 *Aconitum* L.和18种翠雀属 *Delphinium* L.植物的染色体。在12种乌头属植物中，除粗花乌头 *A. crassiflorum* 为四倍体($2n=4x=32$)外，其他种类都为二倍体($2n=2x=16$)，中甸乌头 *A. piepunense* 中有B染色体存在，牛扁亚属 *Aconitum* subgen. *Lycoctonum* 的二倍体植物与乌头亚属 *Aconitum* subgen. *Aconitum* 植物的染色体在大小和形态上有明显区别；所有18种翠雀属植物都为二倍体($2n=2x=16$)，其染色体在大小和形态上极为相似，但与乌头亚属的染色体易于区别。翠雀属植物的核型不对称性程度明显高于乌头属植物，因此从染色体证据来看，翠雀属要比乌头属进化。

关键词 乌头属；翠雀属；染色体；核型进化

（责任编辑 白羽红）